Developments for the '70s:

Meat Chip—A New Snack Idea

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☐ SNACK ITEMS must have gustatory appeal, must be ready to eat, and must be stable at room temperature. Shelf stability may be achieved by processing or packaging, or may be due to properties inherent in the product.

Low moisture means stability —but also toughness

Several chemical factors are involved in stability of meat products. In freeze dried meat, for example, residual moisture above 1½ to 2% will not prevent fat rancidity on storage; in fact, moisture slightly above this level will hasten off-flavor development.

But the chief concern for product stability is control of microbial growth. This control is usually obtained by lowering moisture to a level inhibiting bacterial growth.

Meat snack items now on the shelves tend to be of the dry fermented sausage type. Such snacks are preserved by relatively low moisture, added salts, and acidity. Actually, total moisture in such sausages may average 30%, with the content being perhaps 50% in the non-adipose portions. Without salts or acids, moisture in snack-type sausages would have to be far lower to possess stability.

To remove moisture, diffusion of water vapor and evaporation at elevated temperatures are commonly used. Such drying causes the tissues to shrink and the product to become progressively tougher. While dry sausages contain sufficient moisture to prevent toughness from being a major factor, "jerky," thin strips of dried beef, makes a virtue of toughness. Jerky must be chewed thoroughly to soften and rehydrate the ducive to thoughtfulness. But being tough is not always a virtue.

Deep-fat frying —not for raw meat

The number one snack food, the potato chip, is dried so that it will keep by immersing raw slices of potato into hot fat and boiling the moisture out of the tissues. It seemed logical to try the process on meat.

To remove sufficient water from slices of meat, however, demanded too long a period of cooking in fat. The product was a hardened, shriveled chip which, while it had its devotees, was generally not acceptable.

Meat is not potatoes —tissue structure reacts differently

When potato chips are fried, moisture is vaporized in the interior of the tissue. Cell walls offer some resistance to water vapor passage. The structure is held open until the moisture is removed and replaced by fat. This relative impermeability of the tissue to passage of water vapor is what produces "puff" or "souffle" potatoes.

The structure of meat, on the other hand, permits water vapor to escape with a minimum of resistance. Hence, when the interior moisture is vaporized at high temperature, the vapor passes out quickly and the tissue structure collapses.

Freeze drying can provide suitable structure

The basic problem now emerges: the tissue structure must be kept open while moisture is removed and replaced with fat. Once this is recognized, one answer that suggests itself is freeze drying before frying.

There is some distance, though, between the concept and a practical process. This study was designed to shorten that distance.

The materials

From beef, two whole eyes of the signed to find optimal conditions for making meat chips. Similar muscle tissues were taken from pork and lamb. Turkey and chicken breast meat was used. Chips were made from whole shrimp and from filets of several different kinds of fish.

For comparison, other beef meats were also used, as indicated below.

The process

Meat samples were chilled to between −2 and −4°C. At this temperature, the meat is semi-solid and can be sliced into thin, rigid chips with little or no tissue fluid loss. For all comparison tests, every second or third slice was accorded the same treatment. Slicing was done immediately before freeze drying.

The meat chips were put on trays of a freeze dryer (VirTis 10-145MR-SA) and lyophilized to constant moisture of 2–3%. For convenience, freeze drying was done overnight, although adequate moisture removal required only 4 hours or less. The dry chips were deep-fat fried (in a Dormeyer "Fri-well") and deposited on paper toweling for draining.

Temperature of frying and degree of fat draining were shown to be significant factors.

Because of the open tissue structure left after freeze drying, oil penetration is virtually instantaneous and the cooking process is very rapid. The oil is not taken up into the cell structure; rather, it is held in the chip by capillary action, somewhat as in a sponge.

In frying, chips will shrink, the rate increasing with temperature and becoming important in frying at above 170°C. Below 170°C the chips will be cooked without appreciable shrinkage.

Since fat is held rather than incorporated, % fat tended to vary widely depending on the degree of draining of the cooked chips. A content of one-third fat resulted from simply allowing the chips to rest on the paper toweling. Although no formal tests were run, removal of fat below the level of about one-third was observed to result in chips that felt dry.

The product

The process, when carried out under conditions found suitable (Tables 1 and 2), yields a light brown chip that is chewable and friable, with a satisfying mouthfeel. The chips are crisp when slightly broken up in the mouth. As tissues become partly rehydrated during mastication, a thinness of the slice prevents development of a sensation of toughness from tougher tissue components. Although the chips break up readily on chewing, they are semi-flexible and will not break as easily as do potato chips.

Good color and flavor in the product depend on browning reactions. In deep-fat frying of "wet" meat strips, browning reactions continue for too long a period and impart to the product a dark, almost black color, and a burnt flavor. The short cooking time possible with the freeze dried meat chip allows development of just the right color and flavor properties.

Optimum product studies

Table 1 summarizes results obtained in taste tests conducted to find the most suitable processing conditions. Results reported are those that show significant differences, except where the absence of such differences makes an important point. Moisture was determined by the Karl Fischer method.

The results are hedonic-scale ratings by a ten-member regular panel that had received no special training either in taste testing or in discriminating differences with the particular product. Additionally, responses from a further group of 10 tasters (employed on a more casual basis) were examined and were found to have no effect on the overall results.

Judgments were requested on desirability, odor, flavor, crispness and chewability. As guides in the use of the 9-point scale, odd numbers were identified with the following descriptions: 1—very bad, repellent; 3—bad, dislike; 5—no opinion; 7—good, like; 9—excellent, like very much. Crispness and chewability were also asked to be judged by comparing different samples in any one test and further against recollection of these characteristics in previously tasted samples. Panelists were allowed to salt chips as much as they liked (except in a test where salt was a variable). Comments were invited.

Minute steak vs. meat chip

The first taste test acquainted panelists with the new product and asked a comparison with a product familiar to them, a deep-fat fried minute or chip steak produced from frozen thin slices of meat. Although the panel showed slight preference for the meat chip, the difference was not significant. But the meat chip did receive a much higher crispness score, and

Table 1—Panel test results help establish optimal conditions for producing meat chips.

Expt. No. & Comparison	Factor[b]	Treatment	Average[c]	S²	t	p
1—A: Minute steak; B: Meat chip[a]; n = 9, d.f. = 16	De	A	6.50	2.85	0.77	N.S.
		B	7.11	2.41		
	Cr	A	3.88	0.98	7.03	<0.1%
		B	7.50	1.14		
2—C: 130°C, 30 sec; D: 160°C, 30 sec; n = 10, d.f. = 18	Cr	C	5.4	1.82	1.94	7%
		D	6.5	1.39		
	Ch	C	5.9	3.21	1.55	15%
		D	7.1	2.77		
3—E: 30 sec; F: 15 sec; G: 45 sec; 148°C	E,F,G					N.S.
4—H: 0.030" thick; J: 0.053" thick; K: 0.088" thick; n = 10, d.f. = 18	Cr	H	7.2	1.51	0.91	40%
		J	6.8	0.4	3.29	0.4%
		K	5.2	1.96		
	Ch	H	7.1	1.43	0.98	40%
		J	6.6	1.16	1.52	15%
		K	5.5	4.06		
5—L: Cross; M: With grain; n = 10, d.f. = 18	De	L	7.2	1.29	1.26	20%
		M	6.4	2.72		
	Cr	L	7.2	1.06	3.57	0.2%
		M	5.6	0.93		

[a] All subsequent samples are "meat chips"
[b] The abbreviations used are: De = desirability; Cr = crispness; and Ch = chewability
[c] Ratings on a 9-point hedonic scale

Table 2—Effect of deep fat frying to low moisture content, with and without freeze-drying.

Expt. No. & Comparison	1—A: Without freeze-drying; B: Freeze-dried; n = 7, d.f. = 12						2—C: Without freeze-drying, 2.9% moisture; D: Freeze-dried, 0.58% moisture; n = 8, d.f. = 14					
Factor [a]	De		Fl		Ch		De		Fl		Ch	
Treatment	A	B	A	B	A	B	C	D	C	D	C	D
Average [b]	4.71	7.57	4.71	6.86	5.14	7.14	3.88	6.88	5.63	7.00	6.00	7.13
S^2	2.91	1.29	1.57	2.14	4.14	1.48	4.41	3.55	8.55	2.29	3.71	1.27
t	3.69		2.94		2.23		3.01		1.18		1.42	
p	0.4%		1.5%		5%		1%		30%		15%	

[a] Abbreviations used are: De = desirability; Fl = flavor; and Ch = chewability
[b] Ratings on a 9-point hedonic scale

crispness was considered by most panelists as a desirable characteristic.

The results of this test indicated that the meat chip product was acceptable and desirable.

Effect of frying temperature

Two experiments were run to find the best frying temperature for meat chip production.

Preliminary experiments had indicated that cooking the freeze dried chips above 170°C proceeded too fast to allow accurate timing; over-cooking resulted and gave the product a burnt taste and a dark brown color. On the other hand, panelists rated meat chips made by frying at 130°C as decidedly inferior in quality.

Thus, optimal frying temperature was between 130 and 170°C, and two experiments were run respectively at 148°C and 160°C to see which might be preferable. But cooking for 30 sec at either temperature produced chips which were judged not significantly different by the panel.

Since chips deep-fat fried at 160°C had a less greasy appearance than chips made at 148°C, later experiments were run at the higher temperature. Further, since the quality of chip was as good when frying was 15 sec as when it was 30 sec, the shorter period was selected for all later experimental runs.

Effect of slice thickness

Three thicknesses of meat slices for chip production were examined: 0.030 in., 0.053 in., and 0.088 in. (Globe Model 110 slicing machine settings 0.5, 1.0, and 2.0).

The panel rejected the thickest chip. The other two thicknesses were judged equally acceptable. However, the 0.030 in. chip was very fragile and tended to break during removal from the cooking fat. So, the 0.053 in. meat slice was optimal.

Other factors

An effect of direction of cutting the muscle was examined. Meat chips made from cross-fiber cut slices were preferred slightly over chips from slices cut parallel with the meat fibers. What significance (if any) this preference may have may reside in the relatively crisper product from the cross-fiber slice. However, the parallel-fiber slice gave rise to meat chips that were somewhat sturdier toward handling.

The fat used for cooking made a difference. Peanut oil imparted too much flavor to the meat chips. Both corn oil and cottonseed oil gave good results, and the taste panel was unable to distinguish between the two.

To establish once more that freeze drying was needed to obtain a satisfactory product, a comparison was made between meat chips prepared directly from sliced meat and those prepared by the proposed freeze dry and fry method. The data in Table 2 show lower ratings for flavor, chewability and overall desirability given meat chips produced by frying "wet" slices.

Shelf life

Meat chips were stored for one month in airtight aluminum foil packaging. Taste tests were then run, comparing the stored chips with freshly prepared chips. The taste panel could not detect a difference between fresh and stored chips.

The optimum product

The combination of freeze drying and deep-fat frying produces a desirable, tender, crisp, stable and sturdy product.

In the tests, the best product was produced from meat sliced 0.053 in. thick, freeze dried, and deep-fat fried at 160°C for 15 sec. These parameters are not strictly defined, and further studies should probably be made to pinpoint optimal ranges for specific processing equipment.

Panels gave the chips a good to excellent rating; this is important. The eye rounds used were from ungraded beef of about choice grade, but chips prepared from a commercial frozen minute steak of unknown grade and inferior quality were not judged inferior to eye-round chips. Thus the processing technique may be adaptable to varying grades of meat.

The slight preference for cross-fiber cut chips has been mentioned. This could be of importance in consumer acceptance. On the other hand, greater durability of the parallel-fiber cut chips might more than offset this preference through retention of whole chips in packaging, shipping and handling.

Chips from other meats

Experiments were run and taste tests conducted on chips produced from pork, lamb, chicken, turkey and shrimp. Acceptable chips could be produced from all of these, without adaptation of processing technique.

Chip production from fish was not successful. When the thin slices of fish were freeze-dried, they became very fragile and broke apart during frying. The low solids content of fish muscle appears to be responsible for this fragility.

Final comment

We have not found the technique of cooking freeze dried meat without rehydration to be generally useful—except for the production of a specific item: the meat chip.

What uses the meat chip may have, other than as a ready-to-eat snack, remain to be developed.

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Mention of commercial names of equipment does not imply endorsement by the U.S. Department of Agriculture.